AUTOMATED THEMATIC MAPPING AND CHANGE DETECTION OF ERTS -1 IMAGES

Photointerpretation Results of ERTS-1 Images from the Brownsville, Texas Area

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Technical Report

Prepared for
GODDARD SPACE FLIGHT CENTER
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PREFACE

a. Objectives

The objectives of the photointerpretation task are: to establish the terrain features that can be recognized in the ERTS-1 imagery, to locate ground truth on a specific MSS image and to evaluate the impact of haze and partial cloud cover on the multispectral recognition of crops.

b. Scope of Work

This photointerpretation task was limited to two small areas of the ERTS-1 image No. 1038-16314, which coincided with two frames of RC-8 photography (60,000 feet, aircraft altitude). One frame contains a portion of Cameron County in the coast and is of interest because of the interface between land, fresh water and ocean. The other frame in Hidalgo County, contains small towns and farms. Ground truth exists for some of the farms.

c. Conclusions

The ERTS images have sufficient resolution to identify geographical features such as rivers, islands, lakes, swamps, major highways, canals and farms larger than 40 acres. Farms for which ground truth exists can be identified but haze and substantial cloud cover (about 50%) reduce the usefulness of multispectral techniques for recognizing crops.

d. Recommendations

To extract the enormous amount of information available in the ERTS images an interactive system combining the speed of a digital computer with the flexibility of a photointerpreter is required. Before such a system can be implemented, the role of the computer must be defined by a library of operational earth resource analysis programs. Through such a software library, the photointerpreter will be able to control the computer operations on the ERTS images and will observe the processed images on suitable visual displays.

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1. INTRODUCTION

This report describes the results of a photointerpretation task conducted as part of the investigation titled: "Automated Thematic Mapping and Change Detection of ERTS-1 Images." The task was undertaken for several reasons:

A. Ground truth identified on a map must be located accurately in the ERTS images. The ground truth location is accomplished through the use of larger scale images of the same area from aircraft underflights. The technique had to be tried and refined for ERTS-1 images.

B. A lot of detail is obvious in the ERTS images and most of it can be identified by comparison to maps and aircraft photography. The objects or structures that can be identified give clues as to the information that can be retrieved digitally from the ERTS images.

C. The particular area of interest (near Brownsville, Texas) displays substantial cloudiness and haze during the summer months. Such atmospheric conditions alter the true reflectance of the earth's surface and reduce the accuracy with which resources can be recognized by their multispectral signatures. The ERTS image of the area (see below) was selected as a test case because it displayed broken clouds and haze. The effect of the haze and clouds on the multispectral recognition of crops can be judged by identifying in the ERTS image the farms for which ground truth is available.

2. DESCRIPTION OF TEST SITE AND IMAGES

The map of Figure 1 shows the Brownsville area of Texas. The Gulf of Mexico is to the east of Brownsville and Mexico to the south with the Rio Grande being the border with Mexico. The map shows Kenedy County in the north, Willacy County in the middle with the town of Raymondville, Cameron County in the south with the population centers of Harlinger, San Benito and Brownsville and Hidalgo County in the south-west with the towns of Weslaco, Mercedes, Edinburgh, McAllen and Mission, etc. The area near the Rio Grande (Hidalgo and Cameron counties) consists mostly of irrigated cropland. The map also shows the ERTS-1 test site, the aircraft flight line and the location of two RC-8 camera frames analysed below.

Figure 2 shows the ERTS-1 image (1038-16314) that was utilized. Superimposed on the image are geographic coordinates as well as the area of the test site. The ERTS images obtained from NASA are 9 1/2 inch positive transparencies (black and white) at a scale of 1:1,000,000. To avoid damaging the transparencies, an overlay is made photographically by masking the image. The overlay contains all the borderline annotation of an image including fiducial marks at the corners and geographic tick marks on the edges. Using the geographic tick marks, coordinates (lines of constant latitude or longitude) are drawn on the overlay. Also, the test site is outlined in the overlay. The overlay can then be superimposed and aligned to the image through the use of the fiducial marks as shown on Figure 2. The ERTS-1 image was taken by the satellite on August 30, 1972. On August 31, 1972, an RB57F aircraft flew along the flight path shown in Figure 1, at an altitude of about 60,000 feet.

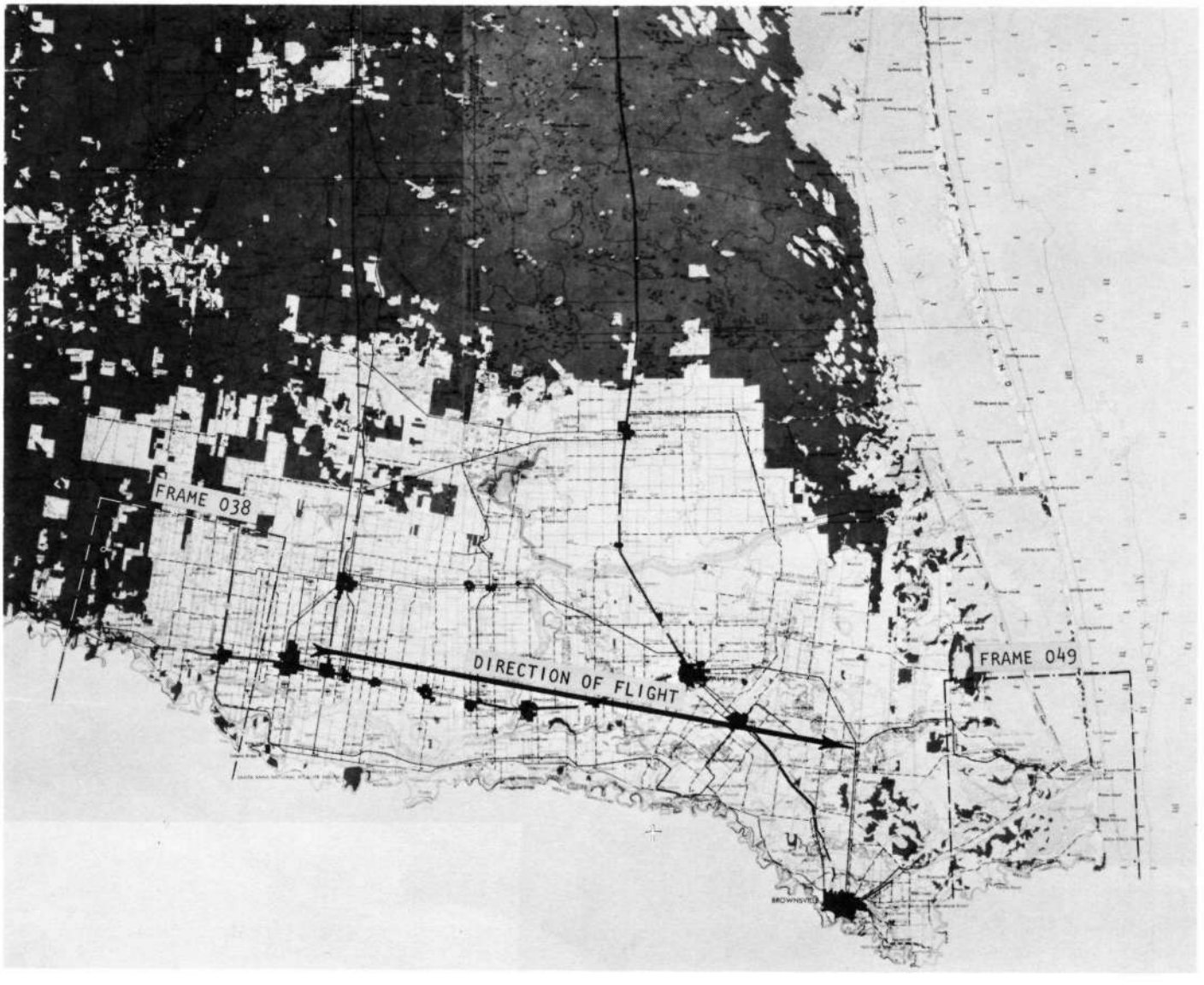

Figure 1. Map of Brownsville Area - Texas

Figure 2. Annotated ERTS-1 Image 1038-16314

The cameras used consisted of two RC-8 cameras (6 inch focal length) and four Hasselblad's (40 mm focal lengths). So, the scale of the photographs obtained were 1:120,000 for the RC-8s and 1:450,000 for the Hasselblad's.

For this task, maps of the area at a scale of 1:250,000 and a photographic copy of a Hidalgo County map (see Figure 3) were also utilized. The Hidalgo County map shows fields for which ground truth exists. For ease in performing the correlation between the ERTS image, the aircraft images and the maps, all images were either enlarged or reduced to the scale of 1:250,000.

3. INTERPRETATION RESULTS

3.1 Bayside Area

Figure 4 shows an enlarged portion of the ERTS image from the red MSS spectral band (0.6 - 0.7 microns). The area shown is the Bayside Area, northeast of Brownsville. The red spectral band provides the most overall information while the other three bands (green, .5 - .6 μ, IR1, .7 - .8μ and IR2, .8 - 1.1 μ) give higher contrast for certain objects. The green band provides the best contrast between waters of different hues such as ocean versus muddy river or between shallow and deep water. The IR2 band gives maximum contrast between water and dry land, and in addition penetrates haze most effectively.

The area shown in Figure 4 matches approximately the area (14 x 14 miles) covered by a specific frame of the RC-8 camera. This frame is shown in Figure 5. Due to the difference on the scales between the ERTS image (1:1,000,000 scale) and the RC-8 image (1:125,000), the RC-8 image has higher resolution while the ERTS image (Figure 2) covers a much larger area. The images compliment each other, but it is desirable for ERTS images to eventually replace aircraft photography for many remote sensing tasks. For this purpose, it is important to determine the smallest objects which can be identified in the ERTS image (Figure 4). Using the four MSS images we first attempted to identify small objects with the aid of the map only (Figure 1). The objects that were identified on this basis are (See Figure 4):

1. The airfield that was recognized from the runways, with the green band providing the best clue.

2. The shrimp boat docks along the channel that joins Brownsville to the Gulf of Mexico. The docks were identified as a high reflectance object against the low reflectance of the surrounding channel water. The IR2 band provides the maximum contrast in this case.

3. The river water from the Brownsville channel, empties into the sea and forms a plume as it mixes with the sea water. The breakwaters in the entrance to the sea are visible in both IR images.

4. Movement of sand and silt from the Brownsville channel into the lagoon along the community of Bayside is evident. Presumably, the silting occurs at high tide.

5. A channel has been cut in the lagoon and it is called the Gulf Intracoastal waterway. Near the town of Bayside the channel and the adjacent spoil banks were easily identified in the green and red band images.

Figure 3. Ground Truth Map of Hidalgo County, Texas
(Courtesy of Dr. C. L. Wiegand, USDA)

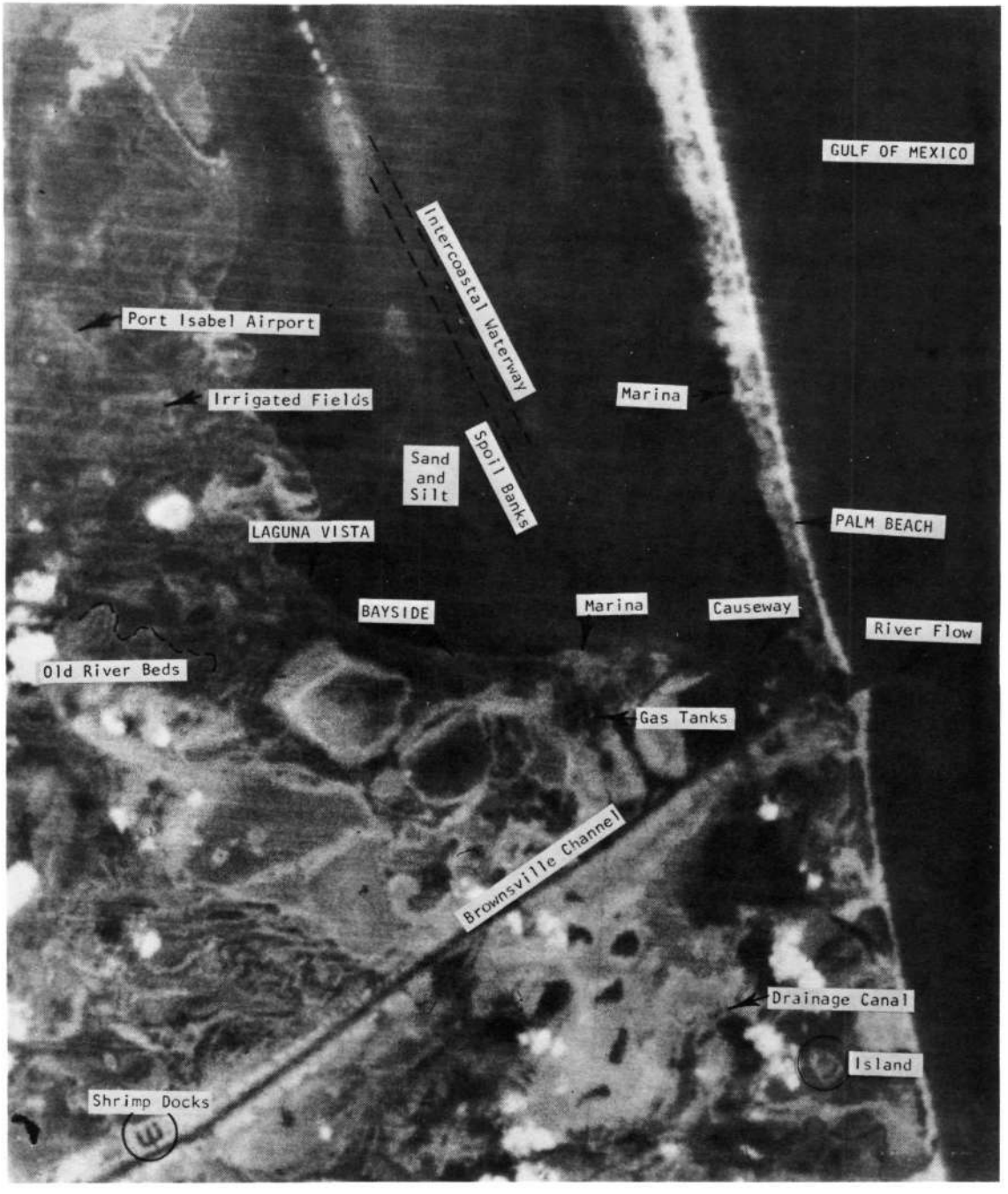

Figure 4. Bayside, Texas Area, ERTS-1 Image

6. A small island in a marsh area (lower right corner of Figure 4) was identified by the island outline and the alternating pattern of marsh grass growth and apparent sand bars. The red band gave the highest contrast for the island.

7. A causeway to the community of Palm Beach on the sand bar that separates the lagoon from the open sea is identifiable in the red and IR bands.

8. Next to the airport there are irrigated fields. These appear to be flooded or wet and are more easily identified in the IR1 and IR2 bands. Shallow water regardless of its color in the visible region shows up dark in the IR2 band. Hence, the IR2 band is the best for identifying surface water.

9. An old river bed near the community of Laguna Vista is visible in the red band.

10. A branch of the Brownsville channel is obvious near the causeway where the channel, and the lagoon meet.

Then, we proceeded to identify small objects with the aid of the aircraft photography. These are objects that can be detected in the ERTS images but cannot be identified with the aid of the map due to lack of detail and inaccuracies in the map. However, it seems possible that if the map was more accurate and was made from recent aircraft photography that all objects could have been identified without the aid of the aircraft imagery.

The following small objects were identified with the aid of the aircraft imagery:

1. In the lower right corner of Figure 4, there is a drainage canal, a portion of which contains significant amount of water. The canal is partially detectable in the IR2 image.

2. In Figure 5 there are four towns visible: Palm Beach occupying a significant portion of the sand bar separating the lagoon from the ocean, Laguna Vista Heights across the causeway from Palm Beach, Bayside lying west of Laguna Vista Heights and Laguna Vista further west. In the ERTS image (Figure 4) there is no indication that there are four towns in the area shown. Light density points in the ERTS image may be associated with Laguna Vista houses but cannot be distinguished from film grain noise.

3. Two marinas, one north of Palm Beach and the other west of Laguna Vista Heights were identified in the red band image.

4. In the vicinity (south) of Laguna Vista Heights there are two gas tanks and a large building. These have been definitely identified in the ERTS image where they appear as an irregularly shaped white spot.

5. Highways and railroads visible in Figure 5 have not been identified in the ERTS image.

3.2 Hidalgo County Area

Figure 6 is an RC-8 photograph of the southern portion of the Hidalgo County. Cross-hatched farms are those identified from the county map (Figure 3).

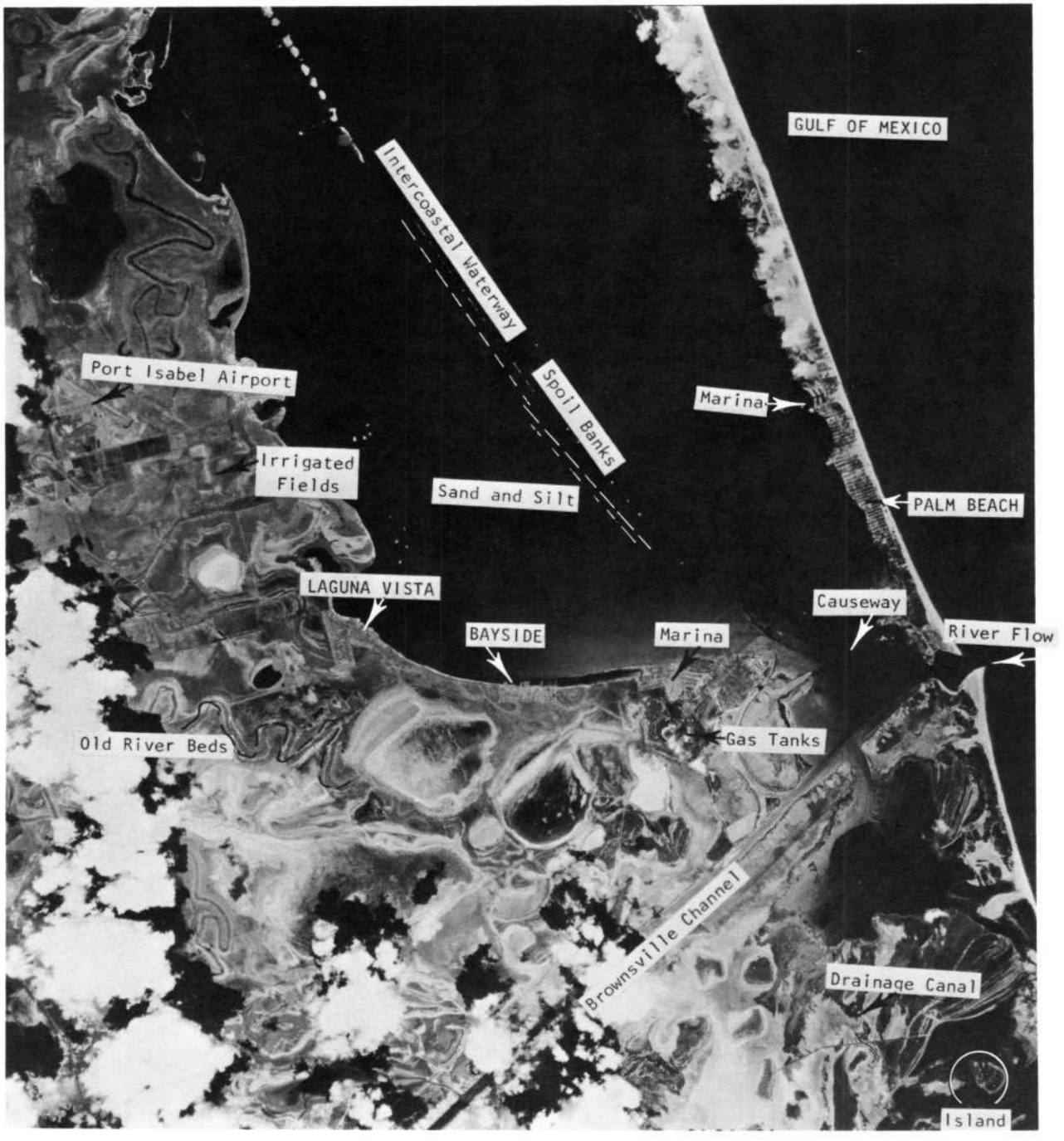

Figure 5. Bayside, Texas Area, RC-8 Photograph

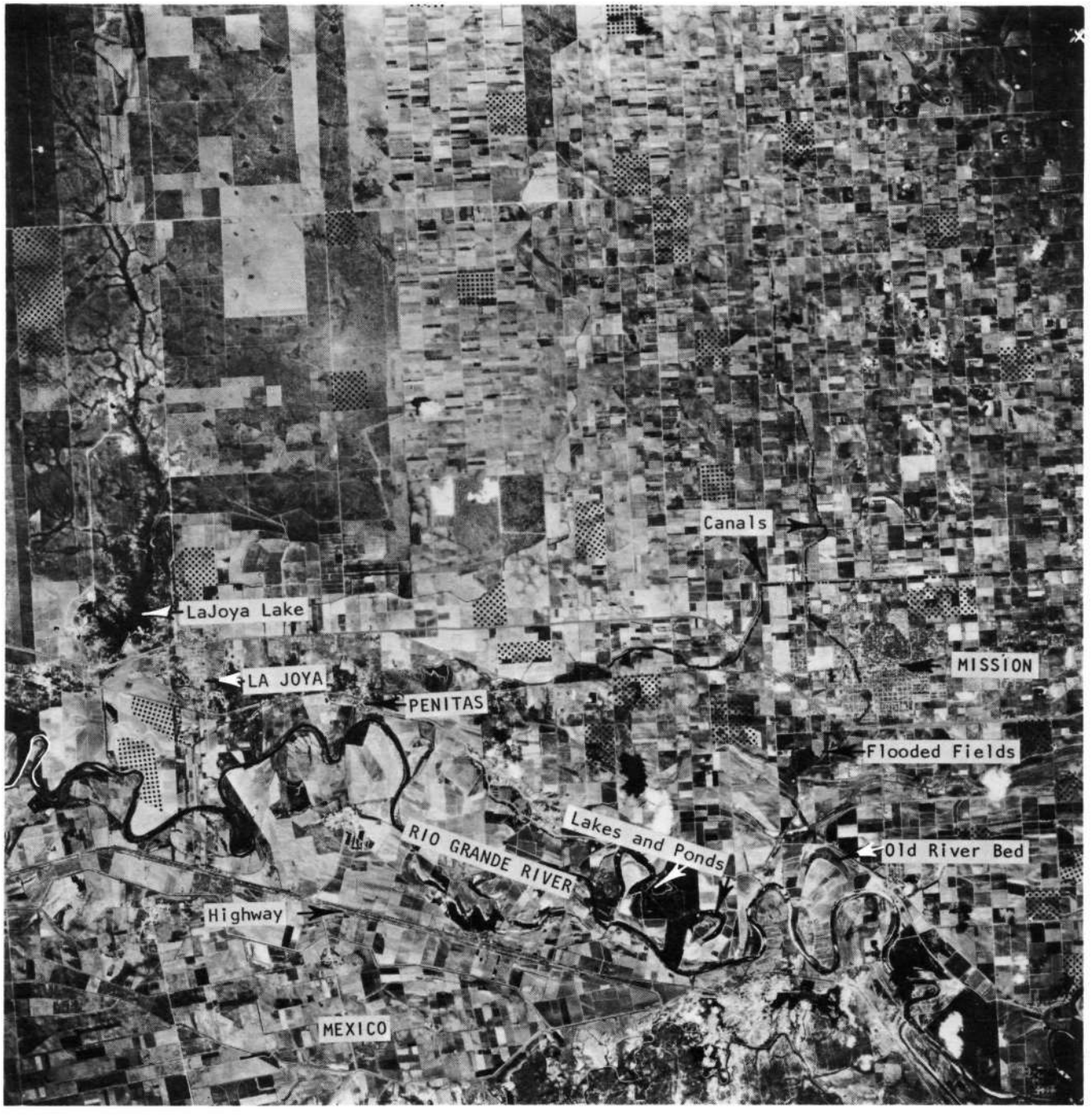

Figure 6. Hidalgo County, RC-8 Annotated Photograph

Figure 7 is a portion of the ERTS image from the red MSS band, showing most of Hidalgo County. Darkened, numbered blocks identify farms corresponding to the numbered farms in the county map. Identification of the farms in the ERTS image was difficult due to cloud cover. Some farms were definitely identified while the rest were outlined by projecting the county map on the ERTS image and using the identified farms and the Rio Grande as control points.

We have noticed some discrepancies in the county map such as an urban area visible in the aircraft image (Figure 6) where the county map shows farms. It appears that the map has not been recently updated.

The area has many 160 acre plots and many of these are subdivided into smaller area crops. The smallest field that can be identified in the ERTS image is about 40 acres (400 x 400 meters) provided a substantial difference in reflectance exists between the field and the surrounding fields.

The ERTS IR2 image (see Figure 8) is best for identifying areas with surface water. These are:

1. Two canals
2. Flooded fields
3. Old river beds
4. Lakes & Ponds

In the red MSS image major highways are visible but smaller roads are not. Several towns visible in the aircraft photography cannot be distinguished from farms in the ERTS images. They may be distinguishable though by digital multispectral analysis or spatial pattern recognition techniques. These possibilities are being examined under two separate tasks of this project.

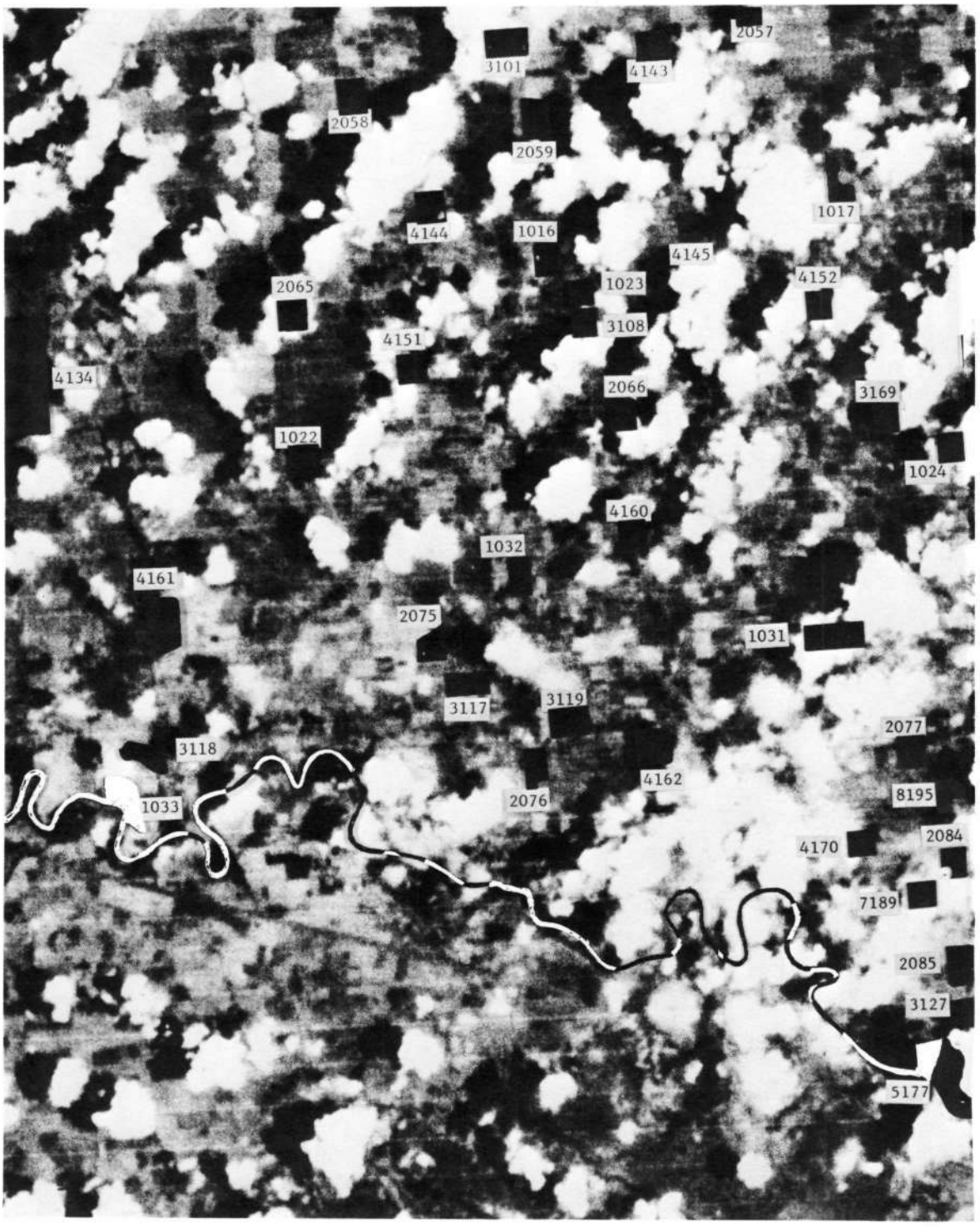

Figure 7. Hidalgo County, ERTS-1 Red Band

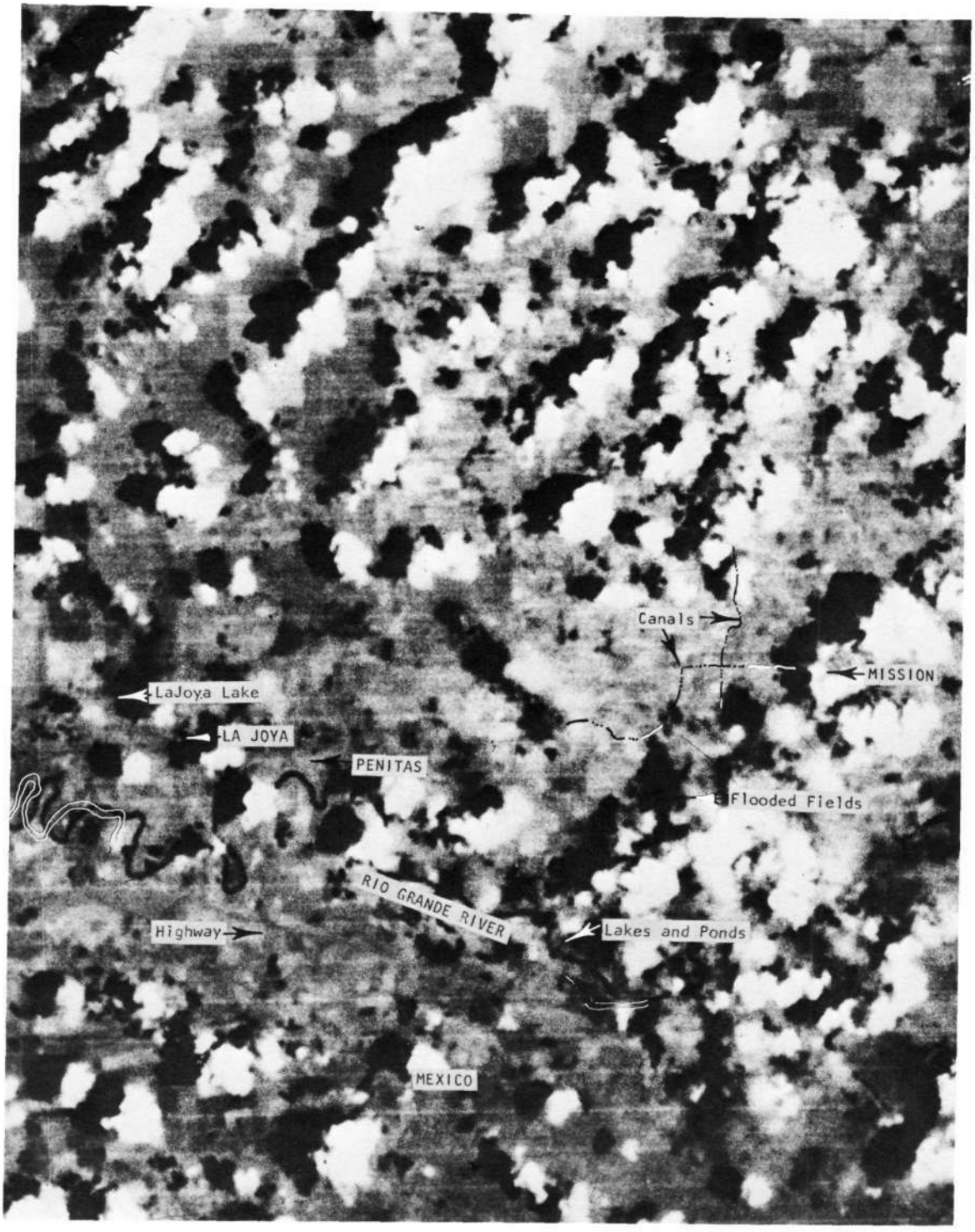

Figure 8. Hidalgo County, ERTS-1, IR2 Band

4. CONCLUSIONS

1. The ERTS images have sufficient resolution for monitoring agricultural resources in crops larger than 40 acres. This conclusion basically agrees with Professor Colwell's findings for ERTS images of California.

2. Substantial cloud cover (about 50%) as is experienced in the ERTS images of this report, greatly reduces the usefullness of a multispectral analysis of farms since most farms of 160 acres or larger are wholly or partially covered by clouds or their shadows.

3. The IR2 band (0.8 - 1.1 μ) gives excellent results for the identification of surface water. Even small bodies of water (about 4 acres) were definitely identified and easily distinguished from cloud shadows. This band does not appear to give information about water depth or clarity, but defines rather precisely the boundaries between wet areas and dry land.

4. Most geographic features such as lagoons, lakes, islands, riverbeds, marshes, large canals, docks can be clearly identified in the ERTS images.

5. The ERTS images provide information for the analysis of river effluents, silting of harbors and the movement of water with the tides.

6. Urban areas are not well identified from spatial characteristics but can be delineated from multispectral signatures.

7. Major highways can be identified but smaller roads are not visible.

8. Haze appears to have reduced the contrast of the ERTS images even though the red, IR1 and IR2 bands are able to penetrate haze.

9. Very small bright objects such as gas tanks or buildings can be detected in the ERTS images and can be identified through the aid of accurate maps.

10. There is an apparent need to update existing maps (1:250,000 scale) of the area.

11. The red band (0.6 - 0.7 μ) has the most information. It carries some of the information available in the other three bands.

12. In the ERTS images there is no evidence of variation in reflectance due to the look angle, while in the aircraft images substantial variation due to look angle and specural reflection from bodies of water was readily apparent.

5. RECOMMENDATIONS

In the ERTS images there is a lot of detail whose significance is not immediately obvious. Manual photointerpretation is a very flexible means for analyzing the ERTS images and extracting information. However, photointerpretation is extremely slow and therefore expensive. On the contrary, digital interpretation techniques provide speed and efficiency but lack flexibility.

To extract the enormous amount of information available in the ERTS images an interactive system combining the speed of a digital computer with the flexibility of a photointerpreter is required. Before such a system can be implemented, the role of the computer must be defined by a library of operational earth resource analysis programs. Through such a software library, the photointerpreter will be able to control the computer operations on the ERTS images and will observe the processed images on suitable visual displays. Digital interpretation techniques leading to an operational software library are now being developed under this and other investigations.

6. ACKNOWLEDGEMENTS

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